Geographic Variation of Mercury and Other Elements in U.S. Coal

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Air Quality V
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Objective Use available coal quality data to illustrate which coals can be used with existing technology to reduce mercury emissions.

1 Data sources

ICR 2 (1999) 25,825 records
<epa.gov/ttn/atw/combust/utiltox/utoxpg.html>

FERC 423 (1999) 19,507 records (also 2002)
<eia.doe.gov/cneaf/electricity/page/ferc423.html>

CTRDB (1992 - 1999) 5,823 records
<eia.doe.gov/cneaf/coal/ctrdb/database.html>

COALQUAL (1973 - 1989) 5,059 records
Bragg, L.J., and others 1997, U.S. Geological Survey Open File Report 97-134.

MSHA (1999) 1,342 records
<msha.gov/STATS/PART50/P50Y2K/A&I/1999/caim1999.exe>

EIA 423 (2002) 584 records
<eia.doe.gov/cneaf/electricity/page/eia423.html>

EIA 906-920 (2004) 476 records
<eia.doe.gov/cneaf/electricity/page/eia906_920.html>

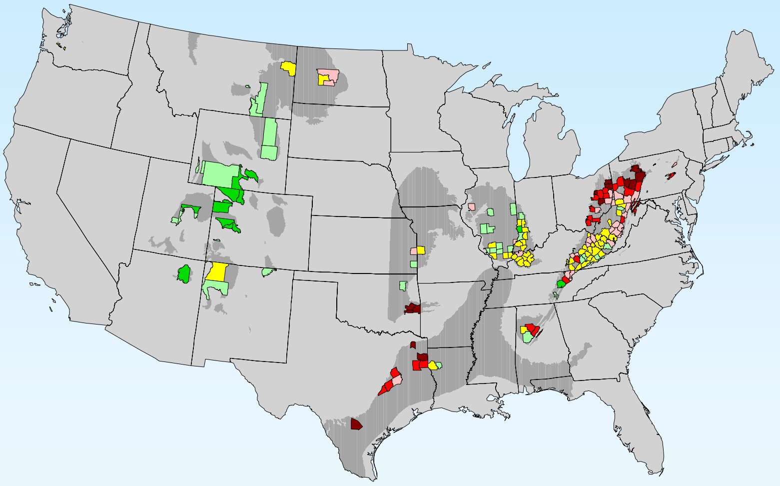
ICR 3 (1999) 240 records
<epa.gov/ttn/atw/combust/utiltox/utoxpg.html>

and analysis of ICR 3 data by:
- **SAIC** (2003) <netl.doe.gov/coal/E&WR/mercury/pubs/DOE_Report_v120803.pdf>
- **ENSR** (2003) <epa.gov/ttn/atw/combust/utiltox/final_ensr_multivar.pdf>
- **Roberson** (2002) <epa.gov/ttn/atw/combust/utiltox/epavarifnl.doc>

CRDB (1997)<eia.doe.gov/cneaf/coal/reserves/database.html>

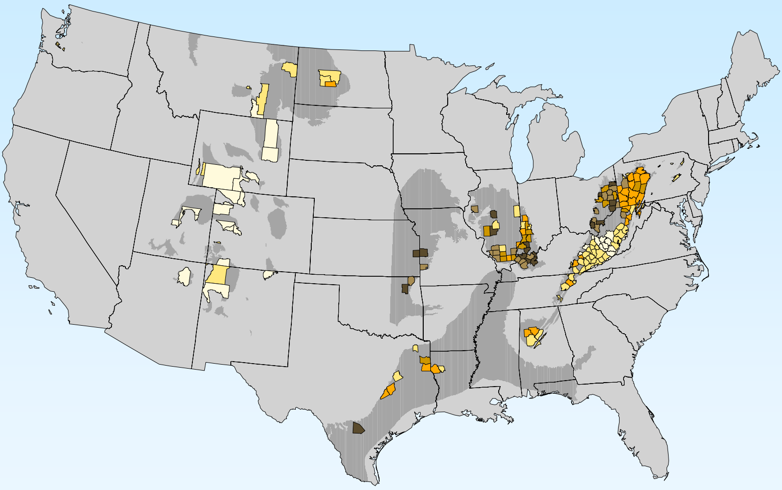
2 Coal quality maps

Mercury
ICR 2 data commercial coal by origin county



lbs / trillion (10^{12}) BTU
- 2 - 4
- 4 - 6
- 6 - 9
- 9 - 15
- 15 - 30
- 30 - 52
- coal province

Sulfur
FERC 423 data commercial coal by origin county

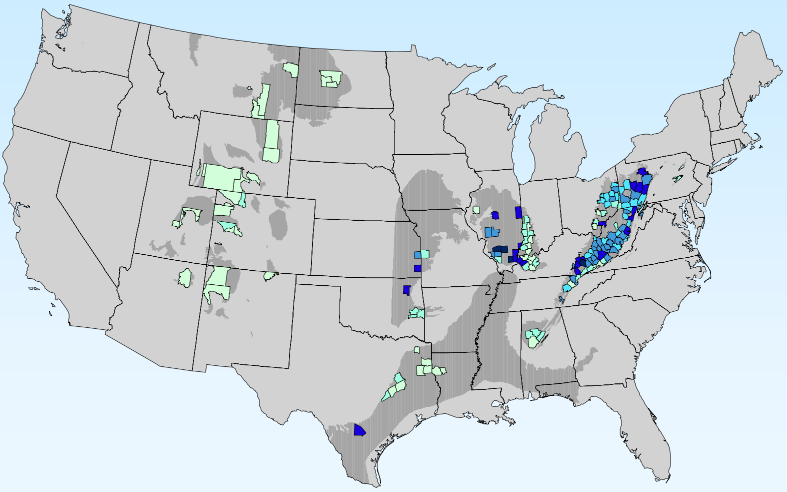


lbs / million (10^{6}) BTU
- 0.3 - 0.7
- 0.7 - 1.2
- 1.2 - 1.7
- 1.7 - 2.3
- 2.3 - 2.9
- 2.9 - 3.8

Chlorine

ICR 2 data
commercial coal
by origin county

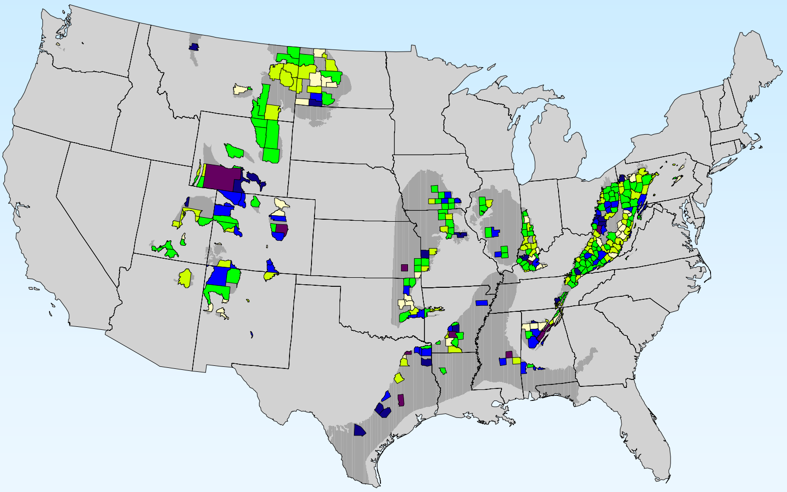
lbs / billion (10^9) BTU
3 - 25
25 - 50
50 - 75
75 - 100
100 - 200
200 - 326



Fluorine

COALQUAL data
in-ground coal
by origin county

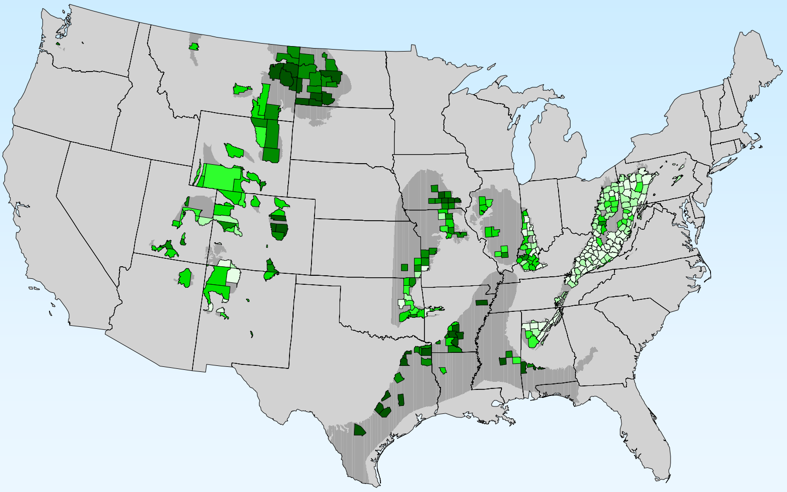
lbs / billion (10^9) BTU
1 - 3
3 - 5
5 - 8
8 - 12
12 - 20
20 - 95



Calcium

COALQUAL data
in-ground coal
by origin county

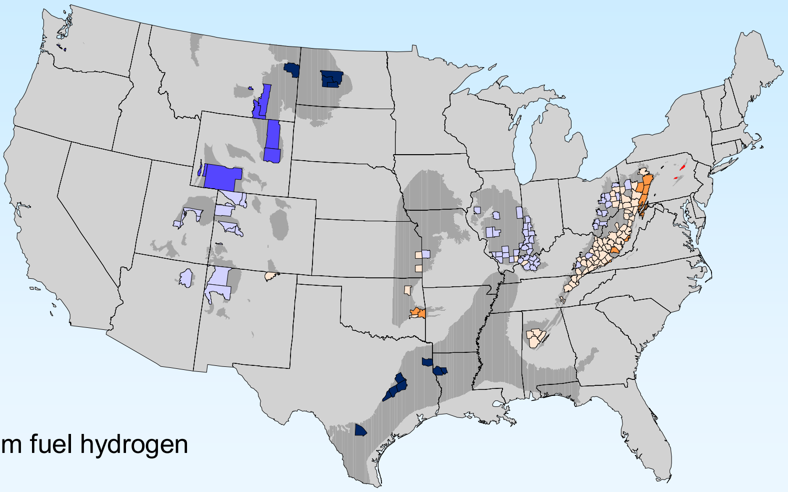
lbs / billion (10^9) BTU
20 - 100
100 - 200
200 - 400
400 - 800
800 - 1500
1500 - 2600



Moisture*

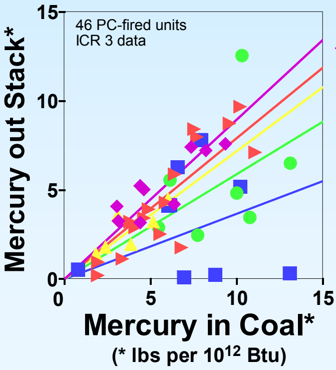
estimated,
commercial coal
by origin county

lbs / million (10^6) BTU
22 -23 (anthracite)
32 - 35
35 - 40
40 - 55
55 - 70
70 - 97



* includes H_2O from fuel hydrogen

3 The significance of the coal mercury content depends on the emission control technology.



hot ESP	$Hg_{out} = 0.9\,Hg_{in}$; $r^2 = 0.75$
cold ESP	$Hg_{out} = 0.8\,Hg_{in}$; $r^2 = 0.76$
hot ESP + FGD	$Hg_{out} = 0.7\,Hg_{in}$; $r^2 = 0.65$
cold ESP + FGD	$Hg_{out} = 0.6\,Hg_{in}$; $r^2 = 0.15$
SDA + fabric filter	$Hg_{out} = 0.4\,Hg_{in}$; $r^2 = 0.00$

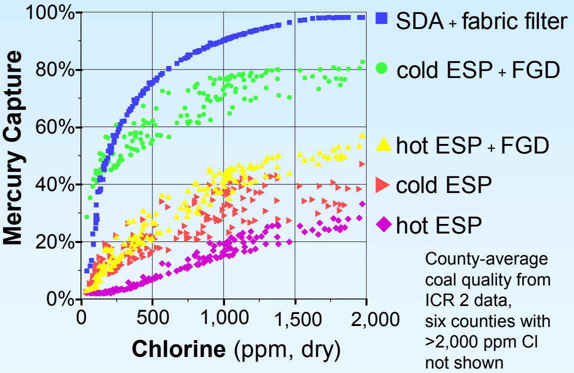
more significant

less significant

4 The average result of equations that predict mercury capture - applied to coal from 162 U.S. counties.

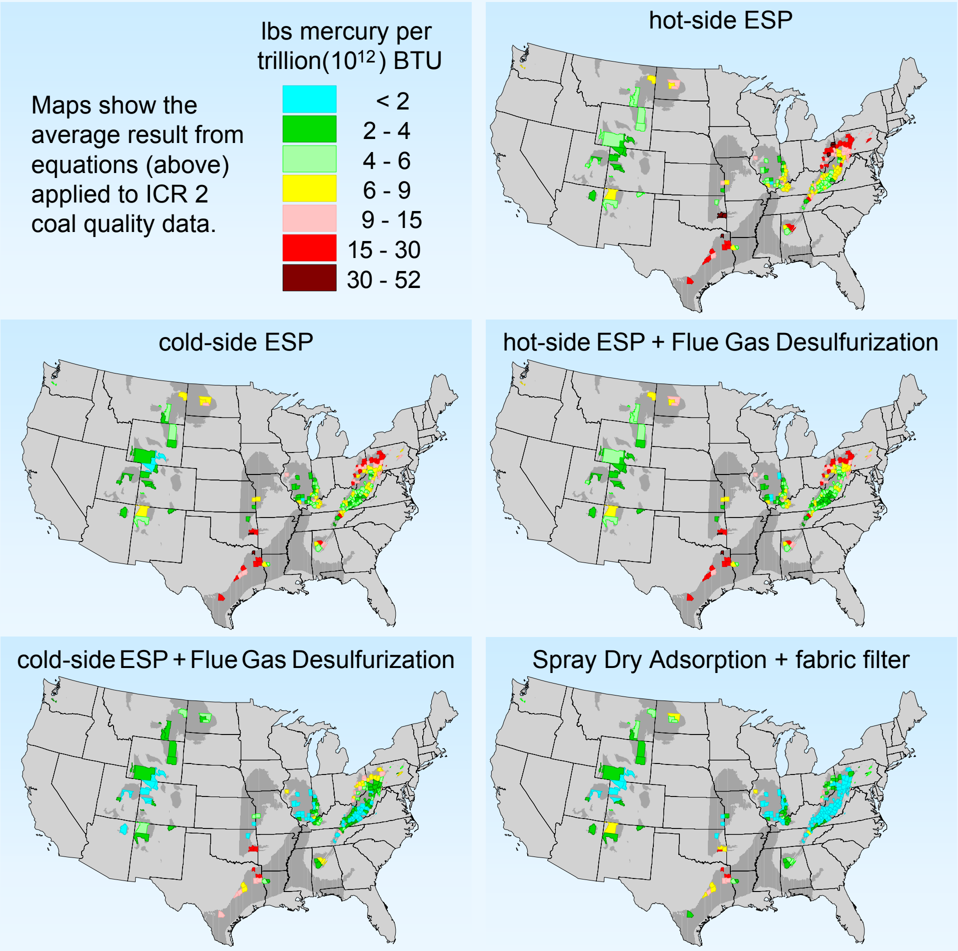
TECHNOLOGY Reference	Equation to Predict Mercury Capture (100% capture = 1)	r^2	n
cESP			
Roberson (2002)	$0.1133\,Ln\left(\frac{Cl_{ppm,dry}}{1.998\,S_{wt.\%,dry}}\right) - 0.2987$	0.53	28
model 2, SAIC (2003)	$1 - Exp\left(-7.33E^{-2} - 3.309\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.47	12
model 1, SAIC (2003)	$1 - Exp\left(1.6374 - 0.18693 Ln\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.38	12
cESP/FGD			
Roberson (2002)	$0.1157\,Ln\left(Cl_{ppm,dry}\right) - 0.1438$	0.70	11
model 1, SAIC (2003)	$1 - Exp\left(1.8529 - 0.27149\,Ln\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.74	8
model 3, SAIC (2003)	$1 - Exp\left(-0.2559 - 2.3343E^{-5}\left(\frac{100\,Cl_{ppm,dry}}{S_{wt.\%,dry}}\right)\right)$	0.73	8
hESP			
model 1, SAIC (2003)	$1 - Exp\left(0.9451 - 9.995E^{-2} Ln\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.42	7
model 3, SAIC (2003)	$1 - Exp\left(0.0611 - 2.169E^{-6}\left(\frac{100\,Cl_{ppm,dry}}{S_{wt.\%,dry}}\right)\right)$	0.54	7
ENSR (2003)	$1 - Exp\left(0.12124 - 1.021E^{-4}\left(Cl_{ppm,dry}\right)\right)$	0.39	9
hESP/FGD			
model 1, SAIC (2003)	$1 - Exp\left(2.7019 - 0.29952\,Ln\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.75	6
model 2, SAIC (2003)	$1 - Exp\left(-3.59E^{-2} - 9.358E^{-6}\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.67	6
model 4, SAIC (2003)	$1 - Exp\left(2.5618 - 0.268 Ln\left(\frac{100\,Cl_{ppm,dry}}{S_{wt.\%,dry}}\right)\right)$	0.42	6
SDA/FF			
Roberson (2002)	$0.2854\,Ln\left(Cl_{ppm,dry}\right) - 1.1302$	0.91	10
model 1, SAIC (2003)	$1 - Exp\left(10.7111 - 1.22628\,Ln\left(lbs\ Cl\ per\ 10^{12}\ Btu\right)\right)$	0.89	10
ENSR (2003)	$1 - Exp\left(-0.19992 - 2.164E^{-3}\left(Cl_{ppm,dry}\right)\right)$	0.94	10

equations derived from ICR 3 data



County-average coal quality from ICR 2 data, six counties with >2,000 ppm Cl not shown

5 Mercury emissions for existing technology by coal origin



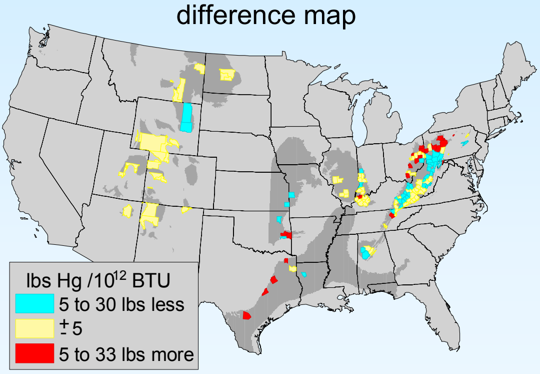
6 Commercial U.S. coal contains less mercury than the in-ground coal …. but not everywhere !

11 lbs Hg/10^{12} BTU **in-ground coal**
(COALQUAL Hg data, CRDB tonnage)

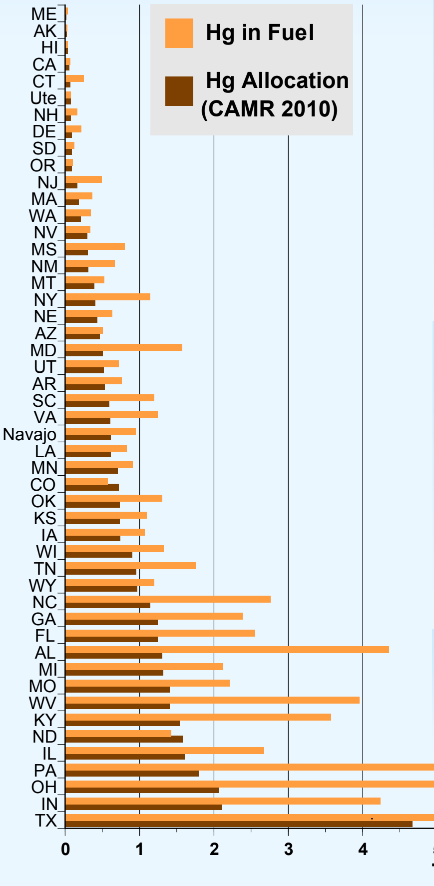
8.3 lbs Hg/10^{12} BTU **commercial coal**
(ICR 2 Hg data, MSHA tonnage)

Red areas show where commercial coal has more mercury than the in-ground coal resource.

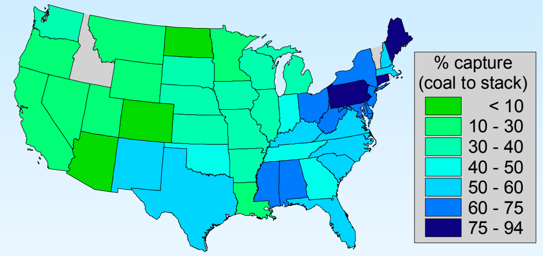
commercial minus in-ground coal Hg difference map



7 2010 CAMR emission targets

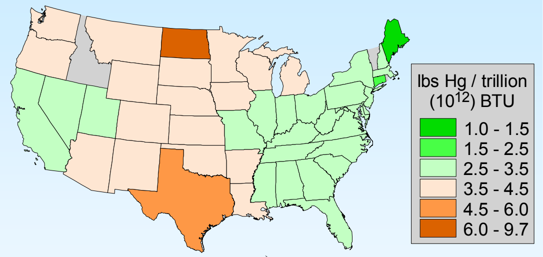


target percent Hg capture (2010)



No CAMR affected units in Idaho or Vermont (grey)

target Hg emission rate (2010)



No CAMR affected units in Idaho or Vermont (grey)

1999 county-average Hg values (ICR 2 data)
2002 state-average fuel origins (FERC and EIA 423 data)
2004 fuel consumption levels (mostly EIA 906/920 data)
2005 Clean Air Mercury Rule (CAMR)

Assumes no trading, no banking, and no change to the amount, origin, or quality of coal.

8 Ways to reduce mercury emissions

500 to 1,000 ppm fuel chlorine: cold-side ESP + FGD
SDA + fabric-filter

low-mercury coal: hot-side ESP
cold-side ESP

selective mining or washing: parts of Pennsylvania, Ohio, and Texas

website: http://geology.utah.gov/emp/mercury/index.htm
comments, corrections, questions, ideas, data… welcome!
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UTAH GEOLOGICAL SURVEY